

Reflective Energies

Subcontractor:	Reflective Energies 22922 Tiagua Mission Viejo, CA 92692-1433
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The Flex-Microturbine™, Running on Low-Pressure, Low-Energy Gases

Reflective Energies is developing a new business that will convert enormous quantities of previously unusable waste into electricity at very low cost. The key technology for the new business is a small, reliable, microturbine electric power plant, the Flex-Microturbine™. The Flex-Microturbine™ will be able to run on fuel gases that are today considered too low in pressure or energy content to produce electric power. It will be able to tap many sources of renewable energy. Flex-Microturbines™ will accept a wide range of low-grade fuel gases while producing lower emissions than "traditional" microturbines. The Flex-Microturbine™ will run on the waste gas now flared from landfill operations, from animal waste and on low-energy gas from the gasification of biomass in addition to waste gases from petroleum and coal production operations. The EPA considers each one of these streams a major environmental hazard and has specific programs for mitigating emissions from each such operation.

Reflective Energies is partnered with Capstone Turbine Corporation, maker of the world's first commercial microturbine power plant and the first to obtain UL approval for the entire power plant. The Flex-Microturbine™ will be adapted from the commercial Capstone MicroTurbine™ line, and will be produced, marketed, and serviced by Capstone.

The Flex-Microturbine™ will create markets not currently available to other microturbines, which require pressurized, high-Btu fuel or expensive fuel gas compressors. By using low-grade fuel that is now going to waste, these plants will produce electricity at significantly lower costs than larger plants. They would also provide major environmental and social benefits, converting damaging waste into electricity. In many cases, the environmental or renewable energy benefits will qualify for subsidies from governments and multilateral institutions pledged to support renewable energy and to combat global warming.

Flex-Microturbines™ will be also run on low-Btu biomass gas from waste wood and crop residues. It will run on fuels well below 100 Btu/scf with no other fuel present. These are important fuels for many developing countries with desperate shortages of power and large quantities of underutilized or destroyed biomass.

Portable plants coupled to small wood gasifiers will be developed and fitted onto flatbed trailers. Instead of moving the fuel to the plant, these plants will be moved from site to site to consume local fuel. This will be especially valuable in the western United States where decades of dying trees and brush pose threats of catastrophic fires, and where huge quantities of unwanted crop and orchard residues are mounting.

In addition to its enormous renewable energy applications, the Flex-Microturbine™ will also be the practical low-cost technology for low-pressure natural gas. The ultra-low emissions and the elimination of the fuel gas compressors will offer compelling advantages over traditional microturbines. Whereas emissions limit the use

of certain natural gas engines, the Flex-Microturbine™ will meet the most stringent emissions requirements anywhere.

The Flex-Microturbine™ creates a fundamental increase in the usefulness of microturbines, and will enhance the quality of life for people all over the world.

The Market

The world market for the Flex-Microturbine™, using only fuels presently wasted, is several hundred thousand megawatts. The projected annual sales for the Flex-Microturbine™ are presented in Table 11. The figures assume that only 1% of the total potential market will be achieved each year.

Table 11. The Flex-Microturbine™ Market Potential

Market	Fuel Source	Potential MW	No. of Units	Units per Year	Revenue @ \$400/kW
			100% of market	1% of market/yr	Annual Gross Rev.
California	Wood/crop residue	1,000	33,000	330	4,000,000
	Landfill Gas	500	16,500	165	2,000,000
	Animal Manure	100	3,300	33	400,000
	Other Waste Gas	1,000	33,000	330	4,000,000
	Total Calif.	2,600	85,800	858	10,400,000
U.S.	Wood/crop residue	10,000	330,000	3,300	40,000,000
	Landfill Gas	10,000	330,000	3,300	40,000,000
	Animal Manure	1,000	33,000	330	4,000,000
	Other Waste Gas	10,000	330,000	3,300	40,000,000
	Total U.S.	31,000	1,023,000	10,230	124,000,000
Worldwide	Wood/crop residue	100,000	3,300,000	33,000	400,000,000
	Landfill Gas	25,000	825,000	8,250	100,000,000
	Animal Manure	20,000	860,000	6,600	80,000,000
	Other Waste Gas	100,000	3,300,000	33,000	400,000,000
	Total Worldwide	245,000	8,085,000	80,850	980,000,000

Market Drivers

There are several reasons why customers will select the Flex-Microturbine™ to generate electricity. Where fuel is a free by-product, electricity will simply be sold for a profit. Renewable energy incentives will enhance the economics. Some customers will even run the Flex-Microturbine™ on low-pressure natural gas to offset high retail electricity costs and to enhance the security of electric supply. President Clinton's Executive Order calling for a threefold increase in bioenergy by 2010 will accelerate the market.

Figure 5 compares the cost of generating electricity from the Flex-Microturbine™ to the cost of wholesale and retail electricity. For low-grade fuel applications the Flex-Microturbine™ beats bulk power prices. For niche applications, the Flex-Microturbine™ beats retail power prices even with natural gas as the fuel. Figure 5 does not take credit for any renewable energy subsidies, buydowns, green power portfolio standards, and pricing. Such subsidies, available in the United States and worldwide, will further enhance the economics.

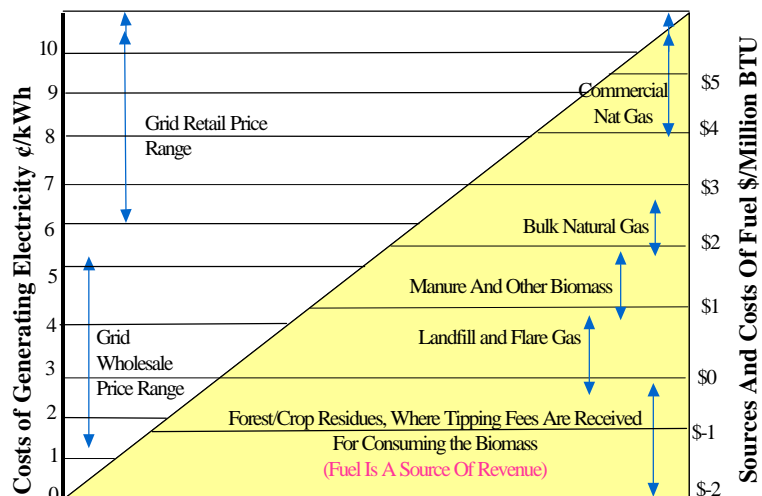


Figure 5. Microturbine generating costs for various fuels compared to traditional generation costs

Even without subsidies, the capital payback period for many of the applications will be between one and three years. This payback will be quickest where fuel is essentially free for the taking, such as in numerous landfill operations today, or where labor is inexpensive.

CURRENT STATUS AND PLANS

The critical technical development work is now complete, supported by important funding from DOE and NREL. Successful safety testing of the new concept performed at the University of California Combustion Laboratory in Irvine. Key partnerships have been established. A development agreement with the EERC, Grand Forks, is underway. Funds for demonstration testing are expected from the DOE and the State of California's PIER program. The first demonstration units are expected in early 2000 with commercial units available in early 2001. Demonstration units will be run on "producer" gas from wood gasifiers, landfill gas, and on digester and petroleum production gases currently being flared.

BUSINESS STRATEGY

Following development of the Flex-Microturbine™ and hand-over of manufacture and marketing to Capstone, Reflective will focus on developing high-value, high-visibility projects for the Flex-Microturbine™ in the United States and elsewhere. There is already a strong market pull for this product, with a large backlog of potential buyers. Interested parties include DOE, the Los Angeles County Sanitation District, the California Department of Forestry, Dane County Landfill in Madison, Wisconsin, NISource, and other landfill and animal digesters around the nation. In addition, the World Bank, the Global Environment Facility, United States Agency for International Development, the United Nations Development Program, the International Finance Corporation, and others have expressed interest in such a dependable renewable energy system that is easily installed, uses local fuel, and creates local jobs. As in the United States, Reflective will develop high-visibility international projects, seeding the market for rapid growth.